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Research

No difference between two types of exercise after proximal phalangeal fracture fixation: a randomised trial

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KEY WORDS

Finger phalanges
Internal fracture fixation
Physical therapy
Articular range of motion
Hand strength

ABSTRACT

Question: Are 6 weeks of synergistic wrist and finger exercises with the metacarpophalangeal joint constrained in an orthosis (constrained exercises) more effective than traditional finger exercises with the metacarpophalangeal joint unconstrained (unconstrained exercises) after open reduction and internal fixation of a proximal phalangeal fracture in terms of impairment, activity limitation and participation restriction at 6 and 12 weeks? **Design:** Randomised, parallel-group trial with concealed allocation, intention-to-treat analysis and blinded outcome assessors. **Participants:** Sixty-six participants within 1 week of open reduction and internal fixation of proximal phalangeal fractures. **Intervention:** The experimental group carried out 6 weeks of synergistic wrist and finger exercises with the metacarpophalangeal joint constrained, whilst the control group carried out finger exercises with the metacarpophalangeal joint unconstrained, as part of a comprehensive rehabilitation program. **Outcome measures:** The primary outcomes were: active proximal interphalangeal joint extension of the injured finger, total active range of motion, and strength. Secondary outcomes were: pain, difficulty with specific hand activity and difficulty with usual hand activity. A blinded assessor measured outcomes at Weeks 1, 6 and 12. **Results:** By Week 6, there were no significant between-group differences in improvement for: active proximal interphalangeal joint extension (MD 2 deg, 95% CI −3 to 7); total active finger range of motion (MD 0 deg, 95% CI −21 to 22); strength (MD −2 kg, 95% CI −8 to 4); pain (MD 1/50, 95% CI −3 to 5); difficulty with specific hand activity (MD 2/60, 95% CI −3 to 8); or difficulty with usual hand activity (MD 0/40, 95% CI −4 to 3). By Week 12, there were also no significant between-group differences in any outcome. **Conclusions:** Constrained and unconstrained exercises has similar effects after open reduction and internal fixation of proximal phalangeal fracture. **Registration:** Australian New Zealand Clinical Trials Registry (ACTRN12610000294055). **[Miller L, Crosbie J, Wajon A, Ada L (2016) No difference between two types of exercise after proximal phalangeal fracture fixation: a randomised trial. *Journal of Physiotherapy* 62: 12–19]**

Introduction

A traumatic finger fracture is a common and often activity-limiting injury,[1–4] especially for unskilled workers and tradespeople who rely on good recovery to return to their employment. Surgical management of people with this injury consists of open reduction and internal fixation with plate and/or screw fixation. This is followed by rehabilitation designed to reduce swelling, minimise scarring and restore range of motion, especially finger extension.

Traditionally, exercise to restore finger range of motion following open reduction and internal fixation involves actively moving the fingers to five positions that combine the three finger joints in combinations of flexion and extension with the wrist in a neutral position. However, in the presence of post-surgical oedema around the proximal phalanx, attempts to extend the finger can result in hyperextension of the metacarpophalangeal joint (MCP), rather than movement across all three finger joints.[5] Over time, this can lead to a flexion contracture at the proximal interphalangeal joint (PIP), known as a pseudo-claw deformity (Figure 1).[6] In two studies with long-term follow-up after open reduction and internal fixation of proximal phalangeal fractures, flexion contractures of the PIP were significant. Horton and colleagues[7] reported an average contracture of 27 deg (SD 15), while Page and Stern[8] reported a contracture $>$ 35 deg or total active range of motion $<$ 180 deg in 38% of injured fingers. This represents approximately one-quarter to one-third of the range of motion in a normal PIP, which is an appreciable limitation for grasping and manipulating objects.

Alternatively, moving the wrist and fingers synergistically may be beneficial.[9] For example, moving between two positions – one being wrist extension with finger flexion and the other being wrist flexion with finger extension – has been shown to produce greater tendon excursion than finger movement alone.[10,11] In addition, constraining joints that compensate for limitation elsewhere with orthoses has been suggested as a way to improve tendon gliding

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Figure 1. Pseudo-claw deformity of the ring finger following proximal phalangeal open reduction and internal fixation.

across joints within the same limb.[6,12,13] The rationale for combining these two ideas – performing synergistic wrist and finger exercises while constraining the MCP in an orthosis – is that it should produce both maximum tendon excursion and maximum joint range in the PIP, thereby preventing flexion contractures.

Therefore, the aim of this study was to investigate whether constrained synergistic exercises were more effective than traditional unconstrained exercises as part of usual care after open reduction and internal fixation. The specific research question was:

> Are 6 weeks of synergistic wrist and finger exercises with the MCP constrained in an orthosis (constrained exercises) more effective than traditional finger exercises with the MCP unconstrained (unconstrained exercises) after open reduction and internal fixation of a proximal phalangeal fracture in terms of impairment, activity limitation and participation restriction at 6 and 12 weeks?

Method

Design

A prospective, parallel-group, randomised clinical trial was conducted, with concealed allocation, intention-to-treat analysis, and blinded outcome assessors. People with proximal phalangeal fracture that required open reduction and internal fixation via plate and/or screw fixation were recruited from the outpatient Hand Clinic at Sydney Hospital following surgery by an independent recruiter not otherwise involved in the trial. The sequence of allocation was computer-generated and concealed in sealed, opaque envelopes by a member of the research team not involved in recruitment. Participants were stratified according to severity of injury. 'Complex' injuries were those fractures that required a dorsal extensor tendon splitting approach and/or were intra-articular fractures, whereas 'simple' injuries included all other fractures. Following baseline measurement, participants were randomly allocated from each stratum, via block randomisation, to one of two groups: 6 weeks of constrained exercises (experimental group) or unconstrained exercises (control group). Participants were measured at baseline within 1 postoperative week (Week 1), after 6 weeks of intervention (Week 6), and 6 weeks beyond the intervention (Week 12). Trained assessors who were blinded to group allocation conducted the measurements at Weeks 1, 6, and 12. To maintain assessor blinding, participants were discouraged from communicating about any part of their intervention and orthoses were removed before measurement. Detailed study procedures are presented in Appendix 1 on the eAddenda.

Participants and therapists

Patients were included if they: were 18 to 65 years of age; had a diagnosis of a finger proximal phalangeal fracture stabilised via open reduction and internal fixation (with plate and screw fixation or screw fixation alone); and gave written, informed consent. They were excluded if they had: co-morbidities including diabetes, active arthropathy, or enchondroma resulting in a pathological fracture; a concomitant tendon or nerve injury; another fracture; a vascular injury; an open fracture; a previous injury to the same finger with residual deformity; or an inability to understand the requirements of the study. Patients were also excluded if: the time between fracture and surgical fixation was $>$ 2 weeks; the time between surgical fixation and initial hand therapy was $>$ 1 week; or they were followed up in another city.

Therapists working at the Sydney Hospital Hand Unit were invited to be the treating therapists if they were working full time in the area of hand therapy at the time of involvement in the trial, and had previous experience in the management of proximal phalangeal fractures following open reduction and internal fixation.

Intervention

All participants undertook up to 12 weeks of rehabilitation. For the first 6 weeks, this consisted of one 40-minute supervised session per week, augmented by a home program. Rehabilitation was aimed at increasing range of motion, decreasing oedema and pain, preventing scarring and preventing secondary harm (Table 1). After 6 weeks, one 30-minute supervised session per week was provided as needed until the participant was discharged or elected to discontinue. During this time, rehabilitation was aimed at increasing both strength and activity (Table 1).

The difference between the experimental group and control group was in the type of active exercises performed to increase joint range of motion during the first 6 weeks of intervention, although the dose was the same. The experimental group performed synergistic wrist and finger exercises with the MCP constrained in a removable orthosis (ie, constrained exercises) for 10 repetitions, six times a day. The orthosis was custom made and fabricated from 3.2 mm thermoplastic material[a]. The orthosis temporarily immobilised the MCP joints of all fingers of the injured hand in approximately 20 deg of flexion. With the orthosis in situ, the interphalangeal joints and wrist remained unimpeded, and the participants performed a sequence of active synergistic wrist and finger movements combining wrist flexion with finger interphalangeal extension and then wrist extension with finger interphalangeal flexion (Figure 2).

The control group performed finger exercises with the MCP unconstrained (ie, unconstrained exercises) for 10 repetitions, six times a day. With the wrist in a neutral posture, participants performed a sequence of active finger movements to five positions (combinations of flexion and extension) for the three finger joints (Figure 3).

All therapists delivering the interventions received training from an investigator (LM) prior to commencement of the trial, and booster sessions throughout the trial. A manual that included week-by-week guidelines was provided. The investigator also undertook in-therapy teaching sessions and case discussions to ensure that the intervention was delivered correctly. Several aspects of the intervention

Table 1
Intervention.

Goal	Weeks 1 to 6	Weeks 7 to 12
Increase range of motion	Active exercises • constrained/unconstrained	Active exercises • constrained/unconstrained Stretches of PIP and MCP
Decrease oedema	Elevation Compression via Coban wrap and/or neoprene sleeve	Compression via Coban wrap and/or neoprene sleeve
Decrease pain	Warm water soaks (from Wk 2) • 10 min/d	Warm water soaks • 10 min/d
Prevent scarring	Scar massage • 5 min × 4/d (from Wk 2) Silicone gel sheet • worn overnight (from Wk 2)	Scar massage • 5 min × 4/d Silicone gel sheet • worn overnight
Prevent secondary harm	Orthosis with MCP in 70 deg flexion, IP joints 0 deg extension • injured and adjacent fingers • worn when at risk and overnight Education outlining activities that can be undertaken safely and those to avoid	Orthosis with MCP in 70 deg flexion, IP joints 0 deg extension • injured and adjacent fingers • worn overnight Education outlining activities that can be undertaken safely and those to avoid
Increase strength	Avoided	Resistance increased from foam sponges to putty
Increase hand activities	Light activities as tolerated	Moderate activities as tolerated

MCP = metacarpophalangeal joint, PIP = proximal interphalangeal joint, IP = interphalangeal joint.

were monitored to ensure fidelity and safety: the amount of exercise, proficiency in exercise, and adverse events. In order to encourage truthfulness, the assessor, rather than the treating therapist, collected the amount of exercise (reported number of exercise repetitions per day over the previous week) at Weeks 6 and 12. In order to maintain blinding, the treating therapist, rather than the assessor, recorded proficiency[14] in exercise (ability to correctly perform the exercises without prompting) at Week 6. The therapist also recorded any adverse events as they occurred, such as re-fracture, infection, and non-union.

Outcome measures

The primary outcomes were impairments (active PIP extension, total active finger range of motion, and strength) and of these, active PIP extension was used for the power analysis. Secondary outcomes were impairment (pain), activity limitations (difficulty with specific hand activity) and participation restrictions (difficulties with usual hand activity).

Active PIP extension was measured using a hand-held finger goniometer[b] and reported in deg. Participants sat at a table with the elbow supported, the forearm vertical, and the wrist in a posture of neutral (0 deg), as recommended by the American Society of Hand Therapists.[15] The assessor immobilised the MCP joint in a posture of neutral (0 deg). Participants were then asked to 'straighten the finger as much as possible until mild discomfort'. The PIP joint angle was then measured via dorsal placement of the goniometer. Hyperextension was denoted as a positive figure. Four assessors were used and, after training, excellent inter-rater reliability was found between them (ICC 0.99, 95% CI 0.97 to 1.0).

Total active finger range of motion was calculated as the difference between composite flexion and composite loss of extension,[16] with any hyperextension (beyond 0 deg) denoted as 0 deg for the purpose of the calculation. Again, measurements were

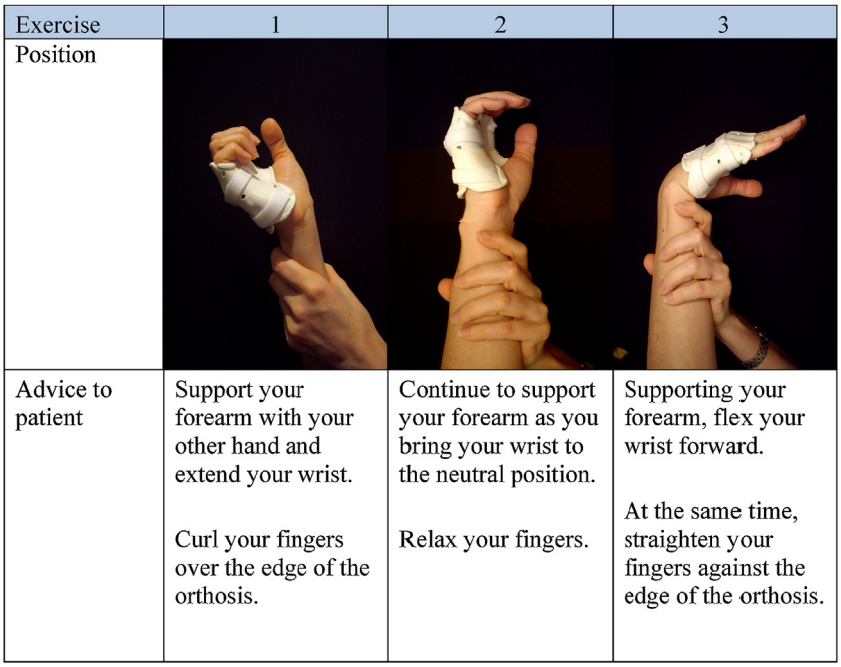


Figure 2. Synergistic wrist and finger exercises with the MCP constrained (experimental group).

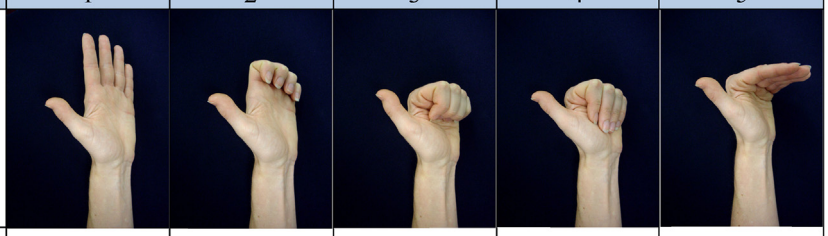
Exercise	1	2	3	4	5
Position					
Advice to patient	Straighten your fingers. Keep your wrist straight.	Curl your fingers into a 'hook' fist. Keep your wrist straight.	Make a full fist. Keep your wrist straight.	Make a fist, but keep the tips of each finger straight. Also keep your wrist straight.	Bend your knuckles into a 'table top' position. Keep your wrist straight.

Figure 3. Finger exercises with the MCP unconstrained (control group).

taken using dorsal placement of a hand-held finger goniometer[b] and reported in deg, with the shoulder, elbow and wrist positioning standardised as before. Participants were asked to 'straighten the fingers as much as possible until mild discomfort', and the MCP, PIP and distal interphalangeal joint (DIP) angles were summed to give composite loss of extension. Participants were then asked to 'make a fist with all the fingers as much as possible until mild discomfort' and the MCP, PIP and DIP angles were summed to give composite flexion.

Strength was measured using a commercially available calibrated hydraulic hand dynamometer[c] and reported in kg. Standardised procedures included positioning (shoulder adducted, elbow 90 deg flexion, neutral forearm and wrist in neutral position)[17] and verbal instruction ('Are you ready? Squeeze as hard as you can. Harder!... Harder!... Relax').[18] The best of three trials was recorded for each hand, with 15 seconds between efforts. Grip strength was not measured at baseline as maximal effort is contraindicated early after fracture fixation.

Pain was measured using the 'pain' component of the Patient-Rated Wrist and Hand Evaluation (PRWHE),[19] which includes severity of pain at rest and during activity as well as frequency of pain. It is scored out of 50, where 0 means no pain. It was not measured at baseline since many of the activities included in the scale are contraindicated early after fracture fixation.

Activity limitation was measured using the 'difficulty with specific activity' component of the PRWHE,[19] which includes activities such as cutting meat and carrying a weight. It is scored out of 60, where 0 means no difficulty with specific activity. It was not measured at baseline since many of the activities are contraindicated early after fracture fixation.

Participation restriction was measured using the 'difficulty with usual activity' component of the PRWHE,[19] which includes personal care, work and recreation activity. It is scored out of 40, where 0 means no difficulty with usual activity. It was not measured at baseline since many of the activities are contraindicated early after fracture fixation.

Data analysis

Based on the published results from two studies that reviewed range of motion following proximal phalangeal open reduction and internal fixation[7,8] it was expected that the control group would achieve an active PIP extension of –27 deg (SD 15). Another 10 to 12 deg of improvement (ie, to –16 deg) was considered to be clinically significant. To be able to detect this difference with 80% power, 30 participants were needed per group. In order to account for 10% drop-outs during the study, a total sample of 66 participants was targeted. In order to ascertain the clinical significance of the findings, the mean between-group difference (95% CI) was calculated for continuous outcomes and the risk difference (95% CI) was calculated for dichotomous outcomes. All participants' data were analysed according to their group allocation, irrespective of compliance to the intervention (ie, via 'intention-to-treat analysis').

Results

Flow of participants and therapists through the study

A consecutive cohort of 155 people returning to the Hand Clinic at Sydney Hospital following open reduction and internal fixation of a proximal phalangeal fracture of any finger was screened for eligibility between May 2010 and December 2013; 89 were excluded or declined to participate (Figure 4). Prior to randomisation, the 66 participants were stratified based on fracture severity and type of fixation into 'complex' (n = 53) or 'simple' (n = 13). At Week 6, 26 participants were analysed in the experimental group and 30 in the control group. Four participants in the experimental group and three in the control group failed to attend their scheduled appointment and were uncontactable. One participant in the experimental group sustained another fracture in the same finger 5 weeks after surgery when lifting a heavy object, and was not assessed at Week 6. One participant in the control group requested to be withdrawn from the trial 2 days after enrolment, whilst another had sustained a concomitant injury and was an inclusion error. At Week 12, 21 participants were analysed in the experimental group, and 27 in the control group. A further five from the experimental group and three from the control group failed to attend their scheduled appointment and were uncontactable at this time. Consequently, outcome measures were obtained from 100% of participants at Week 1, 85% at Week 6, and 73% at Week 12.

At the commencement of the trial, participants (31 experimental and 35 control) were similar in gender, age, side of injury, location of injury, complexity of fracture, fixation type, and hand dominance. The mean age of participants was 34 years (SD 11) and the mean time from surgery to hand therapy was 3.9 days (SD 1.5). See Table 2 for a summary of the characteristics of the participants at baseline.

Three senior (New South Wales Public Hospital Award Level 3 or above) and six junior (Level 1 or 2) therapists working full time in the Sydney Hospital Hand Unit had experience in management of proximal phalangeal fractures following open reduction and internal fixation and acted as treating therapists.

Adherence to trial method

At Week 6, the experimental group performed 100% (6.0, SD 2.1) of the six prescribed exercise sessions per day compared with

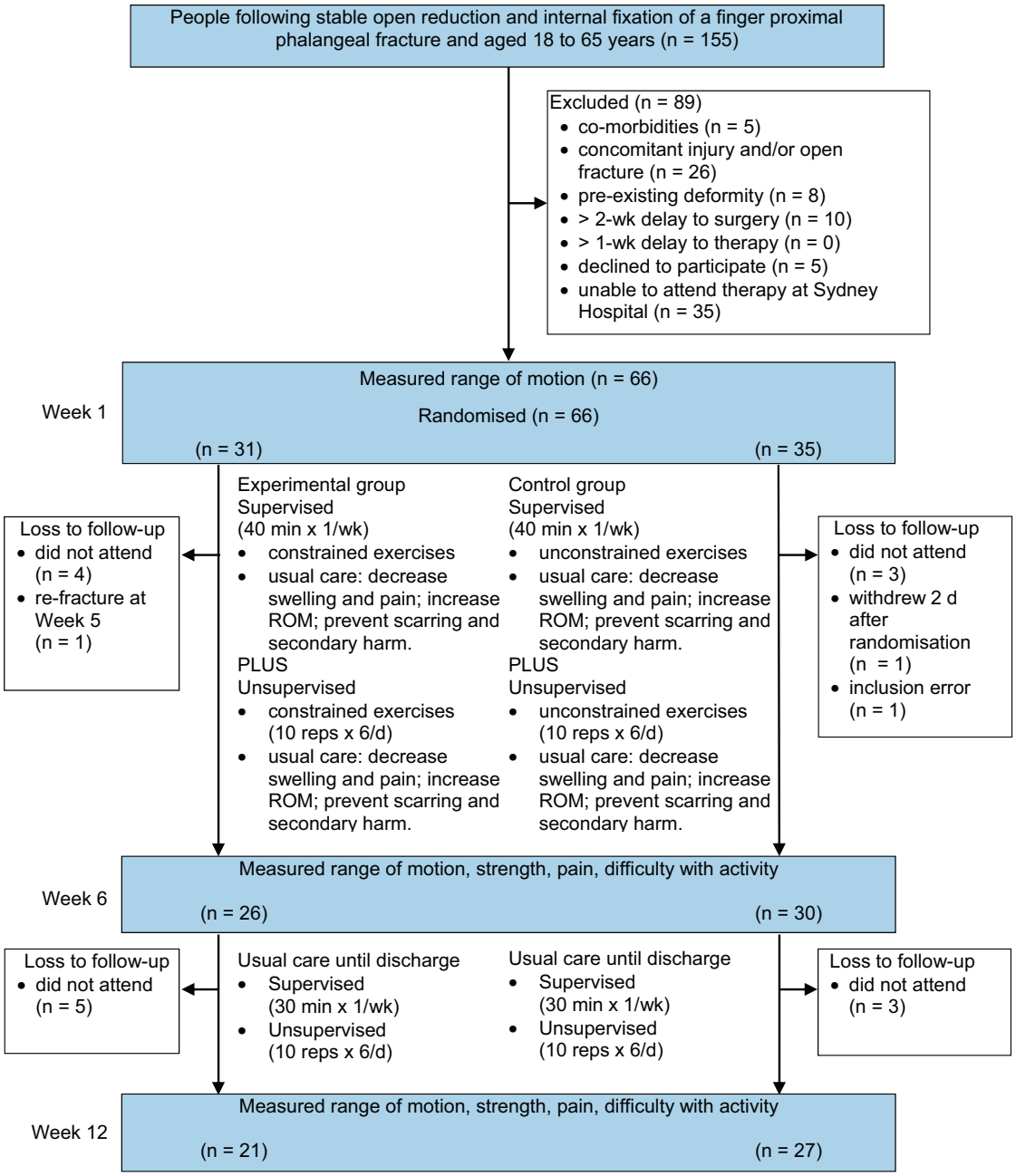


Figure 4. Flow of participants through the trial.

95% (5.7, SD 2.3) for the control group. A total of 85% of the experimental group performed their exercises correctly compared with 100% of the control group. One adverse event occurred: a participant (from the experimental group) sustained a second fracture to the same finger after lifting a heavy object 5 weeks after surgery, and underwent a further open reduction and internal fixation to correct the fracture.

Effect of intervention

By Week 6, there was no significant between-group difference in improvement for: active PIP extension (MD 2 deg, 95% CI −3 to 7); total active finger range of motion (MD 0 deg, 95% CI −21 to 22); strength (MD −2 kg, 95% CI −8 to 4); pain (MD 1/50, 95% CI −3 to 5); difficulty with specific hand activity (MD 2/60, 95% CI −3 to 8); or difficulty with hand usual activity (MD 0/40, 95% CI −4 to 3) (Table 3).

By Week 12, there was also no between-group difference in improvement for: active PIP extension (MD 4 deg, 95% CI −5 to 12); total active finger range of motion (MD −2 deg, 95% CI −27 to 23); strength (MD 1 kg, 95% CI −6 to 7); pain (MD 2/50, 95% CI −2 to 5); difficulty with specific hand activity (MD 2/60, 95% CI −2 to 6); or difficulty with usual hand activity (MD 0/40, 95% CI −2 to 3) (Table 3). Individual participant data are presented in Table 4 on the eAddenda.

Discussion

After open reduction and internal fixation of proximal phalangeal fractures, this randomised clinical trial found no greater effect of 6 weeks of synergistic wrist and finger exercises with the MCP constrained on active PIP extension, total active finger range of motion, grip strength, pain and difficulty with hand activities than traditional finger exercises with the MCP unconstrained. Six weeks later, there was still no effect of the constrained exercises.

There are various explanations for why no difference in outcome was found between the two groups. First, the exercises were only a small part of a comprehensive rehabilitation program. Second, the exercises may have been too similar to each other. Lastly, participants were employed in sedentary or light occupations and most had not sustained their injuries at work, which

Table 2
Baseline characteristics of participants and therapists.

Characteristic	Randomised		Lost to Week 6 follow-up		Lost to Week 12 follow-up	
	Exp (n = 31)	Con (n = 35)	Exp (n = 5)	Con (n = 5)	Exp (n = 10)	Con (n = 8)
Participants						
Age *(yr)*, mean (SD)	32 (9)	36 (12)	30 (10)	36 (12)	31 (12)	32 (12)
Gender, n males (%)	23 (74)	24 (69)	4 (80)	2 (40)	7 (70)	4 (50)
Occupation category, n (%)[a]						
sedentary	12 (38)	7 (20)	0 (0)	1 (20)	1 (10)	1 (13)
light	8 (26)	8 (23)	1 (20)	1 (20)	2 (20)	1 (12)
medium	4 (13)	11 (31)	0 (0)	2 (40)	2 (20)	4 (50)
heavy	4 (13)	6 (17)	2 (40)	1 (20)	3 (30)	1 (12)
very heavy	3 (10)	3 (9)	2 (40)	0 (0)	2 (20)	1 (13)
Dominant hand, n right (%)	28 (90)	31 (89)	5 (100)	4 (80)	5 (50)	6 (75)
Affected hand, n right (%)	11 (35)	19 (54)	3 (60)	4 (80)	6 (60)	7 (88)
Injury mechanism, n (%)						
fall	4 (13)	7 (20)	1 (20)	1 (20)	1 (10)	1 (12)
sport	15 (48)	15 (43)	0 (0)	1 (20)	1 (10)	3 (38)
violence	6 (19)	4 (11)	3 (60)	1 (20)	4 (40)	2 (25)
crush	3 (10)	5 (14)	1 (20)	1 (20)	2 (20)	1 (13)
MVA/BA	0 (0)	1 (3)	0 (0)	0 (0)	0 (0)	0 (0)
other	3 (10)	3 (9)	0 (0)	1 (20)	2 (20)	1 (12)
Work-related injuries, n (%)	1 (3)	3 (9)	0 (0)	0 (0)	1 (10)	0 (0)
Affected finger, n (%)						
index	5 (16)	4 (11)	1 (20)	1 (20)	2 (20)	1 (12)
middle	8 (26)	2 (6)	2 (40)	0 (0)	4 (40)	1 (13)
ring	7 (23)	9 (26)	0 (0)	2 (40)	0 (0)	4 (50)
little	11 (35)	20 (57)	2 (40)	2 (40)	4 (40)	2 (25)
Fracture location, n (%)						
intra-articular base (MCP)	3 (10)	6 (17)	0 (0)	0 (0)	0 (0)	1 (12)
extra-articular base	9 (29)	9 (25)	1 (20)	1 (20)	5 (50)	1 (13)
midshaft	7 (23)	10 (29)	2 (40)	3 (60)	3 (30)	4 (50)
extra-articular distal	6 (19)	3 (9)	1 (20)	1 (20)	1 (10)	1 (13)
intra-articular distal (PIP)	6 (19)	7 (20)	1 (20)	0 (0)	1 (10)	1 (12)
Surgical approach, n (%)						
lateral	3 (10)	3 (9)	1 (20)	0 (0)	1 (10)	0 (0)
dorsal (extensor splitting)	21 (68)	25 (71)	3 (60)	3 (60)	8 (80)	4 (50)
between lateral band and central slip	7 (23)	7 (20)	1 (20)	2 (40)	1 (10)	4 (50)
Fixation screws *(n)*, mean (SD)	4 (2)	5 (2)	4 (2)	4 (2)	4 (2)	4 (2)
Plate and screw fixation, n (%)	11 (35)	21 (60)	1 (20)	3 (60)	5 (50)	4 (50)
Stratification category, n complex (%)	25 (81)	28 (80)	3 (60)	2 (50)	8 (80)	5 (63)
Injury-surgery delay *(d)*, mean (SD)	6 (4)	7 (4)	8 (3)	7 (4)	5 (4)	6 (4)
Surgery-therapy delay *(d)*, mean (SD)	4 (2)	4 (2)	4 (2)	3 (2)	5 (2)	3 (2)
Passive PIP extension *(deg)*, mean (SD)	−13 (9)	−12 (10)	−17 (8)	−16 (11)	−14 (10)	−12 (10)
Pain at rest *(0 to 10 cm)*, mean (SD)	2.0 (1.8)	2.4 (2.1)	2.7 (1.3)	3.1 (1.6)	1.9 (1.4)	2.3 (1.7)
Therapists, n participants treated (%)						
1	13 (42)	15 (43)	2 (40)	1 (20)	4 (40)	1 (12)
2	4 (13)	3 (9)	0 (0)	0 (0)	1 (10)	1 (13)
3	2 (6)	4 (11)	0 (0)	1 (20)	0 (0)	1 (12)
4	5 (16)	4 (11)	0 (0)	2 (40)	2 (20)	2 (25)
5	1 (3)	2 (6)	1 (20)	0 (0)	1 (10)	0 (0)
6	2 (6)	2 (6)	0 (0)	0 (0)	0 (0)	1 (13)
7	1 (3)	4 (11)	0 (0)	1 (20)	0 (0)	2 (25)
8	2 (6)	0 (0)	2 (40)	0 (0)	2 (20)	0 (0)
9	1 (3)	1 (3)	0 (0)	0 (0)	0 (0)	0 (0)

BA = bike accident, Exp = experimental group, Con = control group, MCP = metacarpophalangeal joint, MVA = motor vehicle accident, PIP = proximal interphalangeal joint.
[a] As defined by the Dictionary of Occupational Titles, United States Department of Labor, 1991.

meant that > 90% had returned to work (72% on full duties) at 6 weeks following surgery, compared with 51 days to return to work in those sustaining their finger fracture in the workplace.[3]

Although no difference was found between the groups, both groups improved. Additionally, when all participants were considered together, the outcomes were favourable compared with previous studies of proximal phalangeal fractures. For example, in the present study, by 3 months after surgery, the total active range of motion was 213 deg (SD 41). This compares favourably to a retrospective study at 10 months after surgery, where the total active range of motion was < 180 deg in 36% of participants.[20] It also compares favourably to a randomised trial where 55% of the total active range of motion was regained at 3.3 years after surgery[7] compared with 82% in the present study. Furthermore, in the present study, by 3 months after surgery, the active PIP extension was 13 deg (SD 12) from full extension. This compares favourably with a retrospective study at 6 months, where PIP extension was > 35 deg from full extension in 38% of participants.[8] It also compares favourably with a randomised trial at 3.3 years after surgery, where PIP extension was 27 deg from full extension.[7] This may be due to the fact that rehabilitation was 'best practice' in the present study, in that it started early, was intensive, and exercise performance and frequency were closely monitored. However, it may also be because the majority of participants in the present study were white-collar workers with non-manual jobs or that surgical techniques have improved since the publication of the previous studies.

A limitation of the trial was the loss to follow-up at Week 12. However, there was no systematic difference in characteristics of the participants who were lost to follow-up compared with those who attended all measurements. Furthermore, there was no difference in between-group outcomes at Week 6, when there was little loss to follow-up, and at Week 12. Participant withdrawal is a challenge when managing people with traumatic injuries whose other life-demands continue despite the unplanned injury, limiting attendance at follow-up appointments once the acute period has passed. A further limitation of this trial was that while all measurement procedures at Weeks 1, 6 and 12 were conducted

Table 3
Mean (SD) of groups, mean (SD) difference within groups, and mean (95% CI) difference between groups at Weeks 1, 6 and 12.

Outcome	Groups						Difference within groups				Difference between groups[a]	
	Week 1		Week 6		Week 12		Week 6 minus Week 1		Week 12 minus Week 1		Week 6 minus Week 1	Week 12 minus Week 1
	Exp (n = 31)	Con (n = 35)	Exp (n = 26)	Con (n = 30)	Exp (n = 21)	Con (n = 27)	Exp	Con	Exp	Con	Exp minus Con	Exp minus Con
Impairments												
Active ROM												
PIP ext (*deg*)[b]	–20 (10)	–20 (9)	–14 (9)	–15 (11)	–11 (11)	–15 (13)	6 (9)	4 (11)	10 (15)	6 (13)	2 (–3 to 7)	4 (–5 to 12)
total ext (*deg*)	78 (28)	70 (34)	190 (43)	179 (40)	222 (39)	206 (42)	109 (42)	109 (39)	138 (41)	140 (43)	0 (–21 to 22)	–2 (–27 to 23)
Grip strength (*kg*)			26 (11)	28 (11)	34 (12)	33 (11)					–2 (–8 to 4)	1 (–6 to 7)
Pain (PRWHE) (*0 to 50*)			13 (7)	13 (8)	11 (6)	9 (6)					1 (–3 to 5)	2 (–2 to 5)
Activity limitations												
Difficulty with specific hand activity (PRWHE) (*0 to 60*)			13 (12)	11 (8)	8 (8)	6 (6)					2 (–3 to 8)	2 (–2 to 6)
Participation restrictions												
Difficulty with usual hand activity (PRWHE) (*0 to 40*)			8 (6)	9 (6)	4 (4)	4 (4)					0 (–4 to 3)	0 (–2 to 3)

Exp = experimental group, Con = control group, PIP = proximal interphalangeal joint, ROM = range of motion, PRWHE = Patient Rated Wrist and Hand Evaluation.
[a] Where outcomes were not measured at Week 1, these are simple between-group comparisons.
[b] Minus sign denotes loss of extension.

by blinded assessors, it was impossible to blind participants to their intervention. Although participants in the control group were unaware of the exercises being prescribed to the experimental group (and vice versa), if they had been given the opportunity to see the alternate exercise type, they would have been able to distinguish between them.

There are two main clinical implications from this study. First, constrained exercises have previously been viewed as placing more stress across healing fractures than unconstrained exercises, and have traditionally been used to try to reduce stiffness once it has already developed.[6] The lack of adverse events suggests that it is safe to introduce constrained exercises within the first week after surgery. Second, although neither exercise program was superior to the other, participants in both groups had better outcomes than previously reported, suggesting that the frequency and duration of the present rehabilitation program was beneficial.

What is already known on this topic: Finger exercises are used in rehabilitation after surgical fixation of phalangeal fractures. Attempts at finger extension during these exercises can result in metacarpophalangeal joint hyperextension, which can permit the development of a flexion contracture at the proximal interphalangeal joint. Constraining the metacarpophalangeal joint during the exercises with splinting stops it hyperextending during the exercises.
What this study adds: Although constrained exercises have previously been viewed as placing more stress across healing fractures than unconstrained exercises, and have traditionally been used to try to reduce stiffness once it has already developed, this study shows that it is safe to introduce constrained exercises within the first postoperative week in this population. The exercise regimens used in this study had similar efficacy.

Footnotes: [a] Polyflex II, Patterson Medical Holdings Inc, Bolingbrook, Illinois, USA. [b] Rolyan, Patterson Medical Holdings Inc, Bolingbrook, Illinois USA. [c] Jamar dynamometer, JA Preston Corporation, Clifton, New Jersey, USA

eAddenda: Table 4 and Appendix 1 can be found online at doi:10.1016/j.jphys.2015.11.006

Ethics approval: The SESIAHS Northern Hospital Network and the University of Sydney Human Research Ethics Committees approved this study (reference numbers 09/169 and 12772 respectively). All participants gave written, informed consent before data collection began.

Competing interests: Nil.

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